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**APPLICATION ELEMENTS**

See MPEP chapter 600 concerning utility patent application contents

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(Submit an original, and a duplicate for fee processing)2. ☒ Specification [Total Pages 48]  
(preferred arrangement set forth below)

- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. ☒ Drawing(s) (35 USC 113) [Total Sheets 10]

4. Oath or Declaration [Total Pages 2]

a. ☒ Newly executed (original or copy)b. ☐ Copy from a prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed)  
[Note Box 5 below]i. ☐ **DELETION OF INVENTOR(S)**  
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inventor(s) named in the prior application,  
see 37 CFR 1.63(d)(2) and 1.33(b).5. ☐ Incorporation By Reference (useable if Box 4b is checked)  
The entire disclosure of the prior application, from which a  
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**ACCOMPANYING APPLICATION PARTS**8. ☒ Assignment Papers (cover sheet & document(s))9. ☒ 37 CFR 3 73(b) Statement (when there is an assignee) ☒ Power of Attorney10. ☐ English Translation Document (if applicable)11. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☒ Copies of IDS Citations12. ☐ Preliminary Amendment13. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)14. ☐ Small Entity Statement(s) ☐ Statement filed in prior application,  
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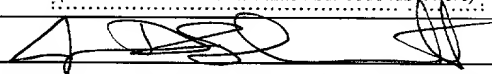
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1 PHASE SHIFTERS, INTERROGATORS, METHODS OF SHIFTING A  
2 PHASE ANGLE OF A SIGNAL, AND METHODS OF OPERATING  
3 AN INTERROGATOR

4 TECHNICAL FIELD

5 The present invention relates to phase shifters, interrogators,  
6 methods of shifting a phase angle of a signal, and methods of operating  
7 an interrogator.

8 BACKGROUND OF THE INVENTION

9 Electronic identification devices, such as radio frequency identification  
10 devices (RFIDs), are known in the art. Such devices are typically used  
11 for inventory tracking. As large numbers of objects are moved in  
12 inventory, product manufacturing, and merchandising operations, there is a  
13 continuous challenge to accurately monitor the location and flow of objects.  
14 Additionally, there is a continuing goal to determine the location of objects  
15 in an inexpensive and streamlined manner. One way of tracking objects  
16 is with an electronic identification system.

17 One presently available electronic identification system utilizes a  
18 magnetic coupling system. In some cases, an identification device may be  
19 provided with a unique identification code in order to distinguish between  
20 a number of different devices. Typically, the devices are entirely passive  
21 (have no power supply), which results in a small and portable package.  
22 However, such identification systems are only capable of operation over  
23 a relatively short range, limited by the size of a magnetic field used to  
24 supply power to the devices and to communicate with the devices.

Another type of wireless electronic identification system is an active wireless electronic identification system. Attention is directed towards commonly assigned U.S. Patent Application Serial No. 08/705,043, filed August 29, 1996, and incorporated herein by reference, which describes such active systems in detail. One such system is sold by Micron Communications Inc., 3176 S. Denver Way, Boise, Idaho 83705 under the trademark Microstamp Engine (TM).

These systems include integrated circuit devices which include an active transponder and are intended to be affixed to an object to be monitored. The devices are capable of receiving and processing instructions transmitted by an interrogator. A device receives the instruction, if within range, then processes the instruction and transmits a response, if appropriate. The interrogation signal and the responsive signal are typically radio-frequency (RF) signals produced by an RF transmitter circuit.

Because active devices have their own power sources, they do not need to be in close proximity to an interrogator or reader to receive power via magnetic coupling. Therefore, active transponder devices tend to be more suitable for applications requiring tracking of a tagged device that may not be in close proximity to an interrogator. For example, active transponder devices tend to be more suitable for inventory control or tracking.

The active transponder is capable of using backscatter communication techniques in responding to an interrogator. The

interrogator outputs a polling signal followed by a continuous wave (CW) signal. The integrated circuit devices are configured to modulate the continuous wave signal in backscatter communication configurations. This modulation typically includes selective reflection of the continuous wave signal. The reflected continuous wave signal includes the reply message from the remote devices which is demodulated by the interrogator.

Certain drawbacks have been identified with the use of backscatter communication techniques. For example, the transmission of the continuous wave signal using the interrogator can desensitize the receiver of the interrogator during reception thereby of reply signals from associated remote devices. In particular, some of the continuous wave signal tends to bleed through to the received reply messages. Such results in degradation of wireless communications.

Systems have been provided which improve wireless communications without the drawbacks associated with conventional devices. Variable phase shifters can be used in such systems. However, conventional variable phase shifters are typically very expensive and typically only operate within a certain specified range, (e.g., 0 to 180 degrees).

## SUMMARY OF THE INVENTION

The present invention includes variable phase shifters, interrogators, methods of shifting a phase angle of a signal, and methods of operating an interrogator.

1 It is desired to reduce power within a modulated return link  
2 continuous wave signal of a coherent backscatter communication system  
3 including an interrogator and at least one remote communication device.  
4 Exemplary remote communication devices include remote intelligent  
5 communication devices and radio frequency identification devices (RFID)  
6 of electronic identification systems.

7 An exemplary interrogator comprises a coherent interrogator  
8 configured to provide backscatter communications. More specifically, the  
9 interrogator is configured to output a forward link communication and  
10 a wireless continuous wave signal using a transmitter. The interrogator  
11 is also configured to output a local continuous wave signal to a receiver  
12 of the interrogator following transmission of the forward link  
13 communication. Provision of the local signal enables coherent operation  
14 of the interrogator. The interrogator is operable to receive return link  
15 communications from at least one remote communication device  
16 responsive to transmission of the forward link wireless communication.

17 The interrogator preferably includes a receiver operable to reduce  
18 the amplitude of a carrier signal of the return link communication. For  
19 backscatter communications, the remote communication device is  
20 configured to modulate the continuous wave signal providing a carrier  
21 component and side band components. The receiver of the interrogator  
22 is preferably configured to reduce the amplitude of the carrier  
23 component while maintaining the amplitudes of the side band  
24 components.

Variable phase shifters are disclosed to adjust the phase angle of the local continuous wave signal using a determined phase shift angle to reduce bleed through. The determined phase shift angle may be varied during operation of the interrogator. According to one aspect of the present invention, a phase shifter includes a power divider configured to provide plural quadrature components of an input signal, such as the local continuous wave signal. Plural mixers are provided to scale the quadrature components using the phase shift angle. A second power divider is provided to combine the scaled quadrature components to shift the phase angle of the input signal by the phase shift angle.

Methods of certain aspects of the present invention provide shifting of a phase angle of an input signal according to a phase shift angle. A method of one aspect includes providing the input signal into plural components. Thereafter, the components are scaled using the phase shift angle and combined to shift the phase angle of the input signal by the phase shift angle.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

Fig. 1 is a block diagram of an exemplary communication system.

Fig. 2 is a front view of a wireless remote communication device according to one embodiment.

1 Fig. 3 is a front view of an employee badge according to another  
2 embodiment.

3 Fig. 4 is a functional block diagram of an exemplary transponder  
4 included in the remote communication device of Fig. 2.

5 Fig. 5 is a functional block diagram of an exemplary interrogator  
6 of the communication system.

7 Fig. 6 is a functional block diagram of an RF section of the  
8 interrogator.

9 Fig. 7 is a functional block diagram of an adaptive canceler of  
10 the RF section.

11 Fig. 8 is a schematic diagram of amplitude detectors and an  
12 amplitude adjuster according to one adaptive canceler configuration.

13 Fig. 9 is a graphical illustration of a summed return link  
14 communication outputted from the adaptive canceler.

15 Fig. 10 is a schematic diagram illustrating one configuration of an  
16 amplitude detector and a phase adjuster of the adaptive canceler.

17 Fig. 11 is a graphical illustration of a received return link  
18 communication.

19 Fig. 12 is a graphical illustration of a summed return link  
20 communication.

21 Fig. 13 is a diagrammatic representation of a forward link  
22 communication and a return link communication within the  
23 communication system.  
24



Fig. 14 is a circuit schematic showing a variable phase shifter used in the adaptive canceler, in one embodiment, and which also has other uses.

Fig. 15 is a graphical illustration of a relationship between I and Q components in the variable phase shifter of Fig. 14.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts" (Article 1, Section 8).

Fig. 1 illustrates a wireless communication system 10 embodying the invention. Communication system 10 comprises an electronic identification system in the embodiment described herein. Further, the described communication system 10 is configured for backscatter communications as described in detail below. Other communication protocols are utilized in other embodiments.

The depicted communication system 10 includes at least one electronic wireless remote communication device 12 and an interrogator 26. Radio frequency communications can occur intermediate remote communication devices 12 and interrogator 26 for use in identification systems and product monitoring systems as exemplary applications.

Devices 12 include radio frequency identification devices (RFID) or remote intelligent communication (RIC) devices in the embodiments

described herein. Exemplary devices 12 are disclosed in U.S. Patent Application Serial No. 08/705,043, filed August 29, 1996. Plural wireless remote communication devices 12 typically communicate with interrogator 26 although only one such device 12 is illustrated in Fig. 1.

In one embodiment, wireless remote communication device 12 comprises a wireless identification device such as the MicroStamp (TM) integrated circuit available from Micron Communications, Inc., 3176 S. Denver Way, Boise, Idaho 83705. Such a remote communication device 12 can be referred to as a tag or card as illustrated and described below.

Although multiple communication devices 12 can be employed in communication system 10, there is typically no communication between multiple devices 12. Instead, the multiple communication devices 12 communicate with interrogator 26. Multiple communication devices 12 can be used in the same field of interrogator 26 (i.e., within the communications range of interrogator 26). Similarly, multiple interrogators 26 can be in proximity to one or more of devices 12.

The above described system 10 is advantageous over prior art devices that utilize magnetic field effect systems because, with system 10, a greater range can be achieved, and more information can be obtained (instead of just identification information). As a result, such a system 10 can be used, for example, to monitor large warehouse inventories having many unique products needing individual discrimination

1 to determine the presence of particular items within a large lot of  
2 tagged products.

3 Remote communication device 12 is configured to interface with  
4 interrogator 26 using a wireless medium in one embodiment. More  
5 specifically, communications intermediate communication device 12 and  
6 interrogator 26 occur via an electromagnetic link, such as an RF link  
7 (e.g., at microwave frequencies) in the described embodiment.  
8 Interrogator 26 is configured to output forward link wireless  
9 communications 27. Further, interrogator 26 is operable to receive reply  
10 or return link wireless communications 29 from devices 12 responsive to  
11 the outputting of forward link communication 27. In accordance with  
12 the above, forward link communications and return link communications  
13 comprise wireless signals, such as radio frequency signals, in the  
14 described embodiment. Other forms of electromagnetic communication,  
15 such as infrared, acoustic, etc. are possible.

16 Interrogator unit 26 includes a plurality of antennas X1, R1, as  
17 well as transmitting and receiving circuitry, similar to that implemented  
18 in devices 12. Antenna X1 comprises a transmit antenna and  
19 antenna R1 comprises a receive antenna individually connected to  
20 interrogator 26.

21 In operation, interrogator 26 transmits the interrogation command  
22 or forward link communication signal 27 via antenna X1.  
23 Communication device 12 is operable to receive the incoming forward  
24 link signal. Upon receiving signal 27, communication device 12 is

operable to respond by communicating the responsive reply or return link communication signal 29. Communications of system 10 are described in greater detail below.

In one embodiment, responsive signal 29 is encoded with information that uniquely identifies, or labels the particular device 12 that is transmitting, so as to identify any object, animal, or person with which communication device 12 is associated.

More specifically, remote device 12 is configured to output an identification signal within reply link communication 29 responsive to receiving forward link wireless communication 27. Interrogator 26 is configured to receive and recognize the identification signal within the return or reply link communication 29. The identification signal can be utilized to identify the particular transmitting communication device 12.

Referring to Fig. 2, one embodiment of remote communication device 12 is illustrated. The depicted communication device 12 includes a transponder 16 having a receiver and a transmitter as described below. Communication device 12 further includes a power source 18 connected to transponder 16 to supply operational power to transponder 16. In the illustrated embodiment, transponder 16 is in the form of an integrated circuit 19. However, in alternative embodiments, all of the circuitry of transponder 16 is not necessarily all included in integrated circuit 19.

Power source 18 is a thin film battery in the illustrated embodiment, however, in alternative embodiments, other forms of power

sources can be employed. If the power source 18 is a battery, the battery can take any suitable form. Preferably, the battery type will be selected depending on weight, size, and life requirements for a particular application. In one embodiment, battery 18 is a thin profile button-type cell forming a small, thin energy cell more commonly utilized in watches and small electronic devices requiring a thin profile. A conventional button-type cell has a pair of electrodes, an anode formed by one face and a cathode formed by an opposite face. In an alternative embodiment, the battery comprises a series connected pair of button type cells.

Communication device 12 further includes at least one antenna connected to transponder 16 for wireless transmission and reception. In the illustrated embodiment, communication device 12 includes at least one receive antenna 44 connected to transponder 16 for radio frequency reception by transponder 16, and at least one transmit antenna 46 connected to transponder 16 for radio frequency transmission by transponder 16. The described receive antenna 44 comprises a loop antenna and the transmit antenna 46 comprises a dipole antenna.

Communication device 12 can be included in any appropriate housing or packaging. Fig. 2 shows but one example of a housing in the form of a miniature housing 11 encasing device 12 to define a tag which can be supported by an object (e.g., hung from an object, affixed to an object, etc.).

1 Referring to Fig. 3, an alternative housing is illustrated. Fig. 3  
2 shows a housing in the form of a card 13. Card 13 preferably  
3 comprises plastic or other suitable material. Plastic card 13 houses  
4 communication device 12 to define an employee identification  
5 badge including the communication device 12. In one embodiment, the  
6 front face of card 13 has visual identification features such as an  
7 employee photograph or a fingerprint in addition to identifying text.

8 Although two particular types of housings have been disclosed, the  
9 communication device 12 can be included in any appropriate housing.  
10 Communication device 12 is preferably of a small size that lends itself  
11 to applications employing small housings, such as cards, miniature tags,  
12 etc. Larger housings can also be employed. The communication  
13 device 12, provided in any appropriate housing, can be supported from  
14 or attached to an object in any desired manner.

15 Fig. 4 is a high level circuit schematic of transponder 16 utilized  
16 in the devices of Figs. 1-3. In the embodiment shown in Fig. 4,  
17 transponder 16 is implemented within monolithic integrated circuit 19.  
18 In the illustrated embodiment, integrated circuit 19 comprises a single  
19 die, having a size of 209 x 116 mils<sup>2</sup>, including a receiver 30,  
20 transmitter 32, microcontroller or microprocessor 34, a wake up timer  
21 and logic circuit 36, a clock recovery and data recovery circuit 38, and  
22 a bias voltage and current generator 42. Integrated circuit 19  
23 preferably comprises a small outline integrated circuit (SOIC) package.  
24

Receiver 30 and transmitter 32 comprise wireless communication circuitry configured to communicate wireless signals.

In one embodiment, communication devices 12 switch between a "sleep" mode of operation, and higher power modes to conserve energy and extend battery life during periods of time where no interrogation signal 27 is received by devices 12, using the wake up timer and logic circuitry 36.

In one embodiment, a spread spectrum processing circuit 40 is included in transponder 16. In this embodiment, signals transmitted and received by interrogator 26 and signals transmitted and received by communication device 12 are modulated spread spectrum signals. Many modulation techniques minimize required transmission bandwidth. However, the spread spectrum modulation techniques employed in the illustrated embodiment require a transmission bandwidth that is up to several orders of magnitude greater than the minimum required signal bandwidth. Although spread spectrum modulation techniques are bandwidth inefficient in single user applications, they are advantageous where there are multiple users, as is the case with the preferred radio frequency identification communication system 10 of the present invention.

The spread spectrum modulation technique of the illustrated embodiment is advantageous because the interrogator signal can be distinguished from other signals (e.g., radar, microwave ovens, etc.) operating at the same frequency. The spread spectrum signals

1 transmitted by communication device 12 and interrogator 26 are pseudo  
2 random and have noise-like properties when compared with the digital  
3 command or reply. The illustrated embodiment employs direct sequence  
4 spread spectrum (DSSS) modulation.

5 In operation, interrogator 26 sends out a command that is spread  
6 around a certain center frequency (e.g, 2.44 GHz). After the  
7 interrogator transmits the command, and is expecting a response, the  
8 interrogator switches to a continuous wave (CW) mode for backscatter  
9 communications. In the continuous wave mode, interrogator 26 does not  
10 transmit any information. Instead, the interrogator just transmits a  
11 radio frequency continuous wave signal. In the described embodiment,  
12 the continuous wave signal comprises a radio frequency 2.44 GHz carrier  
13 signal. In other words, the continuous wave signal transmitted by  
14 interrogator 26 is not modulated. After communication device 12  
15 receives the forward link communication from interrogator 26,  
16 communication device 12 processes the command.

17 If communication device 12 is operating in a backscatter mode,  
18 device 12 modulates the continuous wave signal providing a modulated  
19 continuous wave signal to communicate return link communication 29  
20 responsive to reception of forward communication signal 27.  
21 Communication device 12 may modulate the continuous wave signal  
22 according to a subcarrier or modulation signal. Modulation by  
23 device 12 comprises selective reflection of the continuous wave signal.  
24 In particular, device 12 alternately reflects or does not reflect the



1 continuous wave signal from the interrogator to send its reply. For  
2 example, in the illustrated embodiment, two halves of a dipole antenna  
3 are either shorted together or isolated from each other to send a reply.  
4 Alternatively, communication device 12 can communicate in an active  
5 mode.

6 The modulated continuous wave signal communicated from  
7 device 12 comprises a carrier component and plural side band  
8 components about the carrier component resulting from the modulation.  
9 More specifically, the modulated continuous wave signal output from  
10 device 12 includes a radio frequency continuous wave signal having a  
11 first frequency (2.44 GHz), also referred to as a carrier component, and  
12 a subcarrier modulation signal having a different frequency  
13 (e.g., 600 kHz) and which provides the side band components. In  
14 particular, the side band components are at +/- 600 kHz of the carrier  
15 component. The carrier and side band components are illustrated  
16 in Fig. 11 and Fig. 12.

17 In one embodiment, the clock for transponder 16 is extracted  
18 from the incoming message itself by clock recovery and data recovery  
19 circuitry 38. This clock is recovered from the incoming message, and  
20 used for timing for microcontroller 34 and all the other clock circuitry  
21 on the chip, and also for deriving the transmitter carrier or the  
22 subcarrier, depending on whether the transmitter is operating in active  
23 mode or backscatter mode.  
24





1 the dipole antenna is opened and closed. When the switch is closed,  
2 the antenna becomes the electrical equivalent of a single half-wavelength  
3 antenna that reflects a portion of the power being transmitted by the  
4 interrogator. When the switch is open, the antenna becomes the  
5 electrical equivalent of two quarter-wavelength antennas that reflect very  
6 little of the power transmitted by the interrogator. In one embodiment,  
7 the dipole antenna is a printed microstrip half wavelength dipole  
8 antenna.

9 Referring to Fig. 5, one embodiment of interrogator 26 is  
10 illustrated. The depicted interrogator 26 includes a microcontroller 70,  
11 a field programmable gate array (FPGA) 72, and RF section 74. In  
12 the depicted embodiment, microcontroller 70 comprises a MC68340  
13 microcontroller available from Motorola, Inc. FPGA 72 comprises  
14 an XC4028 device available from Xilinx, Inc. Further details of  
15 components 70, 72, and 74 are described below.

16 RAM 76, EPROM 78 and flash memory 80 are coupled with  
17 microcontroller 70 in the depicted embodiment. Microcontroller 70 is  
18 configured to access an applications program for controlling the  
19 interrogator 26 and interpreting responses from devices 12. The  
20 processor of microcontroller 70 is configured to control communication  
21 operations with remote communication devices 12 during normal modes  
22 of operation. The applications program can also include a library of  
23 radio frequency identification device applications or functions. These  
24

functions effect radio frequency communications between interrogator 26 and communication device 12.

RF section 74 is configured to handle wireless (e.g., radio frequency) communications with remote communication devices 12. DPSK modulation techniques can be utilized for communications intermediate devices 12 and interrogator 26. RF section 74 can include downconversion circuitry for generating in-phase (I) and quadrature (Q) signals which contain the DPSK modulated subcarrier for application to FPGA 72 during return link communications.

Plural antennas, including a transmit antenna X1 and a receive antenna R1 are coupled with RF section 74 for wireless RF communications. Plural RF transmit (TX) ports and RF receive (RX) ports (not shown) are coupled with RF section 74 in a preferred embodiment. Provision of plural TX ports and RX ports enables interrogator 26 to minimize the effects of multipath when communicating with plural remote communication devices 12.

Analog to digital converters 82, 84 provide received analog RF signals into a digital format for application to FPGA 72. In particular, analog to digital converters 82, 84 are implemented intermediate FPGA 72 and RF section 74 for both in-phase (I) and quadrature (Q) communication lines. An additional connection 85 is provided intermediate FPGA 72 and RF section 74. Digital signals output from FPGA 72 via connection 85 are converted to RF signals by RF section 74. Connection 85 can be utilized to transmit phase lock

loop (PLL) information, antenna diversity selection information and other necessary communication information. During forward link communications, FPGA 72 is configured to format communication packets received from microcontroller 70 into a proper format for application to RF section 74 for communication.

FPGA 72 is configured to demodulate return link communications received from remote communication devices 12 via RF section 74. FPGA 72 is configured in the described embodiment to perform I and Q combination operations during receive operations. The described FPGA 74 further includes delay and multiplication circuitry to remove the subcarrier. FPGA 74 can also include bit synchronization circuitry and lock detection circuitry. Data, clock and lock detection signals generated within FPGA 74 are applied to microcontroller 70 for processing in the described embodiment.

Microcontroller 70 is configured to control operations of interrogator 26 including outputting of forward link communications and receiving reply link communications. EPROM 78 is configured to store original code and settings selected for the particular application of communication system 10. Flash memory 80 is configured to receive software code updates which may be forwarded to interrogator 26.

RAM device 76 is configured to store data during operations of communication system 10. Such data can include information regarding communications with associated remote communication devices 12 and status information of interrogator 26 during normal modes of operation.

Referring to Fig. 6, an exemplary embodiment of RF circuitry 74 is illustrated. The depicted RF circuitry 74 includes a transmit path 86 and a receive path 87. In the depicted embodiment, RF section 74 includes a transmitter 90, coupler 91 and power amplifier 92 within transmit data path 86. Receive path 87 includes a receiver 95 comprising processing circuitry 96 and an adaptive canceler 97 in the depicted embodiment.

Communication paths 86, 87 are coupled with respective antennas X1, R1. Transmit path 86 is additionally coupled with FPGA 72 via connection 85. Receive path 87 is coupled with analog-to-digital converters 82, 84 via the I, and Q connection lines.

During communication operations, transmitter 90 is configured to output a radio frequency wireless forward link communication 27 and a radio frequency wireless continuous wave signal using coupler 91 and antenna X1. Further, transmitter 90 is also configured to output a local continuous wave signal using coupler 91. Transmitter 90 is preferably configured to simultaneously output the wireless continuous wave signal using antenna X1, and the local continuous wave signal using coupler 91. The wireless continuous wave signal transmitted via antenna X1 and the local continuous wave signal provided to receiver 95 via coupler 91 have a common frequency (e.g., 2.44 GHz in the described embodiment).

Receiver 95 is operable to receive the return link communications 29 from at least one remote communication device 12

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1 using antenna R1. As described in detail below, adaptive canceler 97  
2 of receiver 95 is configured to receive the local continuous wave signal  
3 from coupler 91. Provision of the local signal provides a coherent  
4 backscatter interrogator 26 including a coherent transmitter 90 and  
5 receiver 95.

6 As previously described, return link communication 29 comprises  
7 a modulated radio frequency continuous wave signal in the described  
8 embodiment. The modulated signal comprises a carrier signal located  
9 at the frequency of the wireless continuous wave signal (e.g., 2.44 GHz),  
10 and side bands located at +/- 600 kHz about the frequency of the  
11 carrier signal. In the described embodiment, receiver 95 is configured  
12 to reduce the power or amplitude of the return link communication.  
13 More specifically, receiver 95 is configured to reduce the power or  
14 amplitude of the carrier signal of the return link communication.

15 In one embodiment, receiver 95 is operable to reduce the  
16 amplitude of the return link communication comprising the modulated  
17 continuous wave signal using the local continuous wave signal. More  
18 specifically, receiver 95 is configured to reduce the amplitude of the  
19 return link communications received by antenna R1 at the common  
20 frequency of the continuous wave signals in the described embodiment.

21 As described in detail below, receiver 95 is configured to receive  
22 the local continuous wave signal from coupler 91 and adjust the  
23 amplitude and phase of the local continuous wave signal. Such  
24 adjustment provides an adjusted continuous wave signal. In particular,



1 the amplitude of the local continuous wave signal is adjusted responsive  
 2 to the amplitude of the modulated continuous wave signal. Preferably,  
 3 the amplitude of the local continuous wave signal is adjusted to match  
 4 the amplitude of the received return link communication. The  
 5 amplitude of the local continuous wave signal is adjusted before  
 6 adjustment of the phase of the local continuous wave signal in the  
 7 described embodiment. Following amplitude and phase adjustment,  
 8 receiver 95 is configured to sum the adjusted continuous wave signal  
 9 with the modulated continuous wave signal. Thereafter, the summed  
 10 return link communication having a reduced amplitude at the frequency  
 11 of the wireless continuous wave signal is applied to processing  
 12 circuitry 96.

13 Referring to Fig. 7, one embodiment of adaptive canceler 97 is  
 14 illustrated. Adaptive canceler 97 is configured to reduce the amplitude  
 15 of return link communications 29. More specifically, during backscatter  
 16 communications, receive path 87 is susceptible to bleed through of the  
 17 wireless continuous wave signal transmitted via antenna X1. More  
 18 specifically, the wireless continuous wave signal communicated via  
 19 transmit antenna X1 can saturate the front end of receiver 95. This  
 20 leakage can desensitize receiver 95 and reduce the quality of wireless  
 21 communications of interrogator 26 with remote communication  
 22 devices 12.

23 Adaptive canceler 97 utilizes the local continuous wave signal  
 24 received from transmitter 90 and coupler 91 to reduce the amplitude





SECRET

1 amplitudes of the respective signals. Other configurations of amplitude  
2 adjuster 110 are possible.

3 Referring again to Fig. 7, coupler 109 is configured to sum the  
4 adjusted continuous wave signal and the received modulated continuous  
5 wave signal to reduce the amplitude of the modulated continuous wave  
6 signal. The summed continuous wave signal or return link  
7 communication is applied to a coupler 118. Coupler 118 is configured  
8 to apply the summed signal to low noise amplifier (LNA) 119 and  
9 amplitude detector 120. Amplitude detector 120 is configured to  
10 measure the amplitude of the summed signal and apply an output signal  
11 to a phase adjuster 121.

12 Phase adjuster 121 is controllable responsive to amplitude  
13 adjuster 110. Once amplitude adjuster 110 and variable attenuator 105  
14 have matched the amplitudes of the adjusted continuous wave signal and  
15 the received return link communication, amplitude adjuster indicates the  
16 match to phase adjuster 121 via a connection 122. Thereafter, phase  
17 adjuster 121 operates to select an appropriate phase shift of the  
18 amplitude adjusted local continuous wave signal.

19 In the described embodiment, phase adjuster 121 is configured to  
20 search across  $360^\circ$  of possible phase adjustments to detect a phase  
21 adjustment of the local continuous wave signal which provides maximum  
22 reduction of amplitude of the received modulated continuous wave signal  
23 at the continuous wave signal frequency. In particular, adaptive  
24 canceler 97 adjusts the phase of the local continuous wave signal

1 following matching of amplitudes of the local continuous wave signal and  
2 the received modulated continuous wave signal as indicated via  
3 connection 122.

4 Referring to Fig. 9, a graphical illustration of the amplitude of  
5 the summed return link communication, represented by reference  
6 numeral 136, is illustrated with respect to corresponding plural phase  
7 adjustments of the local continuous wave signal. In the depicted  
8 illustration, it is shown that a local minimum value 130 corresponds to  
9 approximately  $150^\circ$ . For such a situation following searching of  $360^\circ$ ,  
10 phase adjuster 121 will apply an appropriate control signal to phase  
11 shifter 106 to implement the desired phase shift of approximately  $150^\circ$   
12 to minimize the amplitude of the bleed through of the wireless  
13 continuous wave signal within the received return link communication.

14 Referring again to Fig. 7, the summed return link communication  
15 is applied to low noise amplifier 119 and processing circuitry 96. Phase  
16 adjuster 121 is operable to continuously monitor the amplitude of the  
17 summed return link communication and provide appropriate adjustments  
18 using control signals applied to phase shifter 106 to minimize the  
19 amplitude of the continuous wave signal within the summed return link  
20 communication applied to LNA 119.

21 Referring to Fig. 10, exemplary embodiments of amplitude  
22 detector 120 and phase adjuster 121 are illustrated. Amplitude  
23 detector 120 includes discrete components comprising a diode, resistor  
24 and capacitor.

1 Phase adjuster 121 comprises an analog-to-digital converter 124,  
 2 processor 125 and digital-to-analog converter 126. Processor 125 can be  
 3 configured to execute appropriate algorithms to implement sequential  
 4 phase shifts of the local signal from 0° to 360°. The incremental step  
 5 sizes can be adjusted. Therefore, processor 125 can compare the  
 6 amplitudes of the summed return link communication signal responsive  
 7 to various phase adjustments implemented by phase shifter 106.  
 8 Following selection of an appropriate phase shift, phase adjuster 121 can  
 9 continue to monitor the amplitude of the summed return link  
 10 communication and update the phase shift as necessary to maintain  
 11 maximum reduction of the continuous wave signal within the return link  
 12 communication during communications. The depicted configurations of  
 13 detector 120 and phase adjuster 121 are illustrative and other  
 14 configurations can be utilized.

15 Referring to Fig. 11 and Fig. 12, the received return link  
 16 communication applied to adaptive canceler 97 and the summed return  
 17 link communication output from adaptive canceler 97 are illustrated.  
 18 The received return link communication comprising the modulated  
 19 continuous wave signal is illustrated as signal 132 in Fig. 11. The  
 20 summed return link communication is represented by signal 136  
 21 of Fig. 12.

22 Signal 132 comprises a carrier component 133 and side band  
 23 components 134. In the described embodiment, carrier 133 is centered  
 24 at a frequency of 2.44 GHz and subcarrier side band components 134

are depicted at locations  $\pm 600$  kHz of the carrier component 133. Signal 136 similarly comprises a carrier component 137 and side band components 138. Signal 136 includes carrier component 137 at a frequency of 2.44 GHz and side band components 138 at locations  $\pm 600$  kHz of the carrier component 137.

As illustrated, the output summed return link communication signal 136 has a carrier component 137 having a reduced amplitude compared with the carrier component 133 of the received return link communication signal 132. Preferably, the amplitude of side band components 138 of summed return link communication signal 136 are maintained during the reduction of amplitude of the carrier component 137 as illustrated in Fig. 11 and Fig. 12.

In the depicted illustrations of Fig. 11 and Fig. 12, carrier component 137 of signal 136 is approximately 20 dBm less than carrier component 133 of received return link communication 132. Such indicates the reduction of amplitude of the return link communication signal at the frequency of the wireless continuous wave signal (e.g., 2.44 GHz) utilizing adaptive canceler 97.

Referring to Fig. 13, a diagrammatic illustration of forward link communication 27 and return link communication 29 is shown. Initially, forward link communication 27 is communicated using transmit antenna X1 of interrogator 26. Following an intermediate delay or guard band, return link communication 29 corresponding to remote communication device 12 is communicated.

Individual return link communications 29 include a calibration period 140 followed by a preamble 141 and actual data 142. Matching of amplitudes of the local continuous wave signal and the received return link communication and cycling through phases from 0 to 360° utilizing phase adjuster 121 and phase shifter 106 preferably occurs during calibration period 140. The minimum level 130 within the summed return link communication signal is preferably determined during calibration period 140.

Preamble 141 can be utilized to synchronize the processing circuitry 96 of receiver 95 with the actual return link communication 29 being received. Thereafter, data 142 communicated from remote communication device 12 is received. Adaptive canceler 97 is configured to make adjustments as necessary to the amplitude and phase of the local continuous signal during preamble period 141 and data period 142 to maintain maximum reduction of the continuous wave signal within the received return link communication 29.

Fig. 14 illustrates a variable phase shifter 106 in accordance with one embodiment of the invention. Conventional phase shifters available in the marketplace could be employed; however, these are extremely expensive. The phase shifter 106 illustrated in Fig. 14 is an inexpensive alternative. Additionally, the phase shifter 106 provides phase shifts of anywhere from 0 to 360 degrees.

The depicted phase shifter 106 uses a commonly available part known as an IQ upconverter or IQ downconverter 201. The IQ



upconverter or IQ downconverter 201 includes a first power divider 200 defining an input 210 and having two outputs 212 and 214, a second power divider 208 defining an output 202 and having two inputs 204, 206, and two mixers 216 and 218.

The mixer 216 is coupled between the output 212 of the first power divider 208 and the input 204 of the second power divider 200. The mixer 218 is coupled between the output 214 of the first power divider 208 and the input 206 of the second power divider 200.

In the described arrangement, first power divider 200 comprises a ninety degree power divider and second power divider 208 comprises a zero degree power divider. Power divider 200 receives an input signal having a phase angle from input 210 which is the amplitude adjusted local continuous wave signal received from variable attenuator 105 previously described.

Power divider 200 provides a ninety degree phase shift to the input signal to provide a first component and a second component in accordance with one embodiment of the invention. Inasmuch as power divider 200 provides a ninety degree phase shift, first and second components of the received signal may be referred to as quadrature components. In particular, the first component from output 212 is indicated as a cosine component ( $\text{Cos}(\omega t)$ ) and the second component from output 214 is indicated as a sine component ( $\text{Sin}(\omega t)$ ). The signal components  $\text{Cos}(\omega t)$  and  $\text{Sin}(\omega t)$  have a sine/cosine relationship as they are shifted ninety degrees from each other. The quadrature signal

1 components shifted ninety degrees apart are applied to respective  
2 mixers 216, 218.

3 The depicted phase shifter 106 further includes plural digital-to-  
4 analog (D/A) converters 224, 226, I, Q drivers 220, 222, and storage  
5 device 228. Phase adjuster 121 is coupled with storage device 228. A  
6 second input 203 of phase shifter 106 is provided intermediate phase  
7 adjuster 121 and storage device 228.

8 As previously described, phase adjuster 121 is configured to  
9 calculate a desired phase shift angle (also referred to herein as  $\Phi$ ) and  
10 apply the phase shift angle to storage device 228. More specifically,  
11 phase shifter 106 is configured to adjust the phase of the amplitude  
12 adjusted local continuous wave signal received from variable  
13 attenuator 105 responsive to control signals from phase adjuster 121 and  
14 corresponding to the phase shift angle. Appropriate control signals are  
15 generated within phase adjuster 121 to indicate the desired phase shift  
16 angle for shifting of the phase of the amplitude adjusted local  
17 continuous wave signal. In particular, the control signals correspond to  
18 the desired phase shift adjustment to provide the local minimum  
19 value 130 within the summed return link communication signal as  
20 previously described. The control signals identifying the proper phase  
21 adjustment are applied to phase shifter 106.

22 Storage device 228 comprises a look-up table in an exemplary  
23 embodiment. Such a look-up table may be implemented within  
24 an EPROM in one embodiment. Storage device 228 can have one

1 degree resolution, or other resolutions if desired. Storage device 228  
 2 is configured to store a plurality of sine values and cosine values, also  
 3 referred to as I and Q digital values. Further, storage device 228 is  
 4 configured to output one of the stored cosine values and one of the  
 5 stored sine values to the respective D/A converters 224, 226 responsive  
 6 to and corresponding to the received phase shift angle determined by  
 7 phase adjuster 121. For example, if a 45 degree phase shift is desired  
 8 as indicated from phase adjuster 121, storage device 228 outputs digital  
 9 look-up table values of 0.707, 0.707 (i.e., cosine and sine of 45 degrees)  
 10 which are provided to D/A converters 224, 226.

11 Storage device 228 is coupled with D/A converters 224, 226 which  
 12 in turn are coupled with respective I and Q drivers 220, 222. The  
 13 cosine and sine digital values outputted from storage device 228 are  
 14 converted to analog voltages within D/A converters 224, 226. The  
 15 corresponding analog voltage signals from D/A converters 224, 226 are  
 16 applied to respective I and Q drivers 220, 222 to implement the proper  
 17 phase shift within the outputted signal to minimize bleed through.

18 I driver 220 is coupled to mixer 216 and Q driver 222 is coupled  
 19 to mixer 218 as illustrated. Mixers 216, 218 are configured to scale  
 20 the respective cosine and sine components of the input signal  $\cos(\omega t)$ ,  
 21  $\sin(\omega t)$  using the phase shift angle of phase adjuster 121. In the  
 22 described configuration, mixers 216, 218 individually act as multipliers  
 23 and multiply the cosine and sine components of the input signal by the  
 24 respective cosine and sine values from storage device 228 as provided

to I and Q drivers 220, 222. More specifically, mixers 216, 218 multiply the cosine and sine components  $\cos(\omega t)$ ,  $\sin(\omega t)$  of the input signal by voltages outputted by the respective I driver 220 and the Q driver 222 and corresponding to the cosine value and sine value outputted from storage device 228.

By adjusting the values outputted by the I driver 220 and the Q driver 222, a phase shift of anywhere between 0 degrees and 360 degrees can be obtained. Exemplary phase adjustments are described hereafter. Because the input signal components  $\cos(\omega t)$  and  $\sin(\omega t)$  are ninety degrees out of phase, if combined at the second power divider 200 comprising a zero degree power divider without use of multipliers 216, 218, the summed components represented as vectors would have the same value as the input signal plus a ninety degree phase shift of the input signal.

Assume, for example, that the input signal has a constant phase and an amplitude of 1. If the output signal is desired to have the exact same phase, then the I driver 220 is set to provide one volt to the mixer 216 and the Q driver 222 is set to provide zero volts to the mixer 218. Thus, the signal applied to output 202 would be the same as the signal received from input 210.

If a ninety degree phase shift is desired, the I driver 220 would be set to provide zero volts to mixer 216 so there is no signal at output 204, and the Q driver would be set to provide one volt to mixer 218 to produce a ninety degree phase shifted value at the

1 output 202. To produce a 45 degree phase shift, the I driver 220 is  
2 set to provide 0.707 volts and the Q driver is set to provide 0.707  
3 volts so by vector addition, the signal at the output 202 is shifted 45  
4 degrees from the signal at the input 210.

5 Fig. 15 illustrates the relationship between the I and Q signals  
6 applied to the mixers 216, 218, respectively. The relationship is a  
7 sine/cosine relationship. Appropriate I and Q values may be determined  
8 for any other desired degree phase shift (i.e., 0 - 360 degrees). For  
9 example, if a 45 degree phase shift is desired (i.e.,  $\Phi$  equals 45  
10 degrees), I is at 0.707 (i.e.,  $\cos \Phi$ ) while Q is at 0.707 (i.e.,  $\sin \Phi$ )  
11 as determined within storage device 228. Such cosine and sine values  
12 are provided to the respective I and Q drivers 220, 222.

13 Referring again to Fig. 14, the signals outputted from  
14 mixers 216, 218 may be referred to as scaled quadrature cosine and  
15 sine components, respectively. The scaled quadrature component from  
16 mixer 216 may be indicated as  $(\cos(\Phi)\cos(\omega t))$  and the scaled  
17 quadrature component from mixer 218 may be indicated as  
18  $(\sin(\Phi)\sin(\omega t))$ .

19 The scaled quadrature components are applied to second power  
20 divider 208. Power divider 208 is configured to combine the first  
21 scaled quadrature component received from mixer 216 with the second  
22 scaled quadrature component received from mixer 218 to shift the phase  
23 angle of the local continuous wave signal by the phase shift angle  
24 received from phase adjuster 121.

1 In general, the phase of the signal passing within phase  
2 shifter 106 may be represented as  $I + Q$  where  $I = \cos(\Phi)\cos(\omega t)$   
3 and  $Q = \sin(\Phi)\sin(\omega t)$ . Power divider 208 is configured to add the  
4 scaled first and second quadrature components received from  
5 mixers 216, 218 to implement phase shifting operations providing the  
6 adjusted continuous wave signal at output 202. The adjusted continuous  
7 wave signal having a phase angle shifted by the desired phase shift  
8 angle  $\Phi$  is outputted from phase shifter 106 and may be applied via  
9 output 202 to power divider 107 and coupler 109.

10 As previously described, coupler 109 is configured to sum the  
11 adjusted continuous wave signal and the received modulated continuous  
12 wave signal. Such reduces the amplitude of the modulated continuous  
13 wave signal at the frequency of the continuous wave to reduce bleed  
14 through of the carrier signal.

15 In compliance with the statute, the invention has been described  
16 in language more or less specific as to structural and methodical  
17 features. It is to be understood, however, that the invention is not  
18 limited to the specific features shown and described, since the means  
19 herein disclosed comprise preferred forms of putting the invention into  
20 effect. The invention is, therefore, claimed in any of its forms or  
21 modifications within the proper scope of the appended claims  
22 appropriately interpreted in accordance with the doctrine of equivalents.  
23  
24

1        CLAIMS:

2            1.     A phase shifter comprising:

3                a first power divider configured to receive a signal and provide  
4 plural quadrature components of the signal;

5                plural mixers coupled with the first power divider and configured  
6 to scale the quadrature components using a phase shift angle; and

7                a second power divider coupled with the mixers and configured  
8 to combine the scaled quadrature components to shift the phase angle  
9 of the input signal by the phase shift angle.

10  
11            2.     The phase shifter according to claim 1 wherein the first  
12 power divider comprises a ninety degree power divider configured to  
13 provide the signal into a sine component and a cosine component.

14  
15            3.     The phase shifter according to claim 1 further comprising  
16 a storage device configured to store plural sine values and plural cosine  
17 values and to output a sine value and a cosine value individually  
18 corresponding to the phase shift angle.

19  
20            4.     The phase shifter according to claim 1 further comprising  
21 a storage device configured to store a sine value and a cosine value  
22 individually corresponding to the phase shift angle.

1           5.     The phase shifter according to claim 4 wherein the mixers  
2     are coupled with the storage device and individually configured to  
3     multiply one of the quadrature components by one of the sine value  
4     and the cosine value.

5  
6           6.     The phase shifter according to claim 1 wherein the second  
7     power divider comprises a zero degree power divider configured to add  
8     the scaled quadrature components.

9  
10          7.     A phase shifter comprising:  
11             a first input configured to receive a signal having a phase angle;  
12             a second input configured to receive a phase shift angle;  
13             a first power divider coupled with the first input and configured  
14     to provide the signal into a first component and a second component;  
15             a first mixer coupled with the first power divider and the second  
16     input and configured to scale the first component using the phase shift  
17     angle;  
18             a second mixer coupled with the first power divider and the  
19     second input and configured to scale the second component using the  
20     phase shift angle; and  
21             a second power divider coupled with the first mixer and the  
22     second mixer and configured to combine the first scaled component and  
23     the second scaled component to shift the phase angle of the input  
24     signal by the phase shift angle.



1           8.    The phase shifter according to claim 7 wherein the first  
2 power divider comprises a ninety degree power divider configured to  
3 provide the signal into quadrature components.  
4

5           9.    The phase shifter according to claim 7 wherein the first  
6 power divider is configured to provide the signal into a sine component  
7 and a cosine component.  
8

9           10.   The phase shifter according to claim 7 further comprising  
10 a storage device coupled with the second input and being configured to  
11 store plural sine values and plural cosine values and output a sine  
12 value and a cosine value individually corresponding to the phase shift  
13 angle.  
14

15           11.   The phase shifter according to claim 7 further comprising  
16 a storage device configured to store a sine value and a cosine value  
17 individually corresponding to the phase shift angle.  
18

19           12.   The phase shifter according to claim 11 wherein the mixers  
20 are coupled with the storage device and individually configured to  
21 multiply one of the first and second components by one of the sine  
22 value and the cosine value.  
23  
24

1           13. The phase shifter according to claim 7 wherein the second  
2 power divider comprises a zero degree power divider configured to add  
3 the first scaled component and the second scaled component.

4  
5           14. An interrogator of a backscatter communication system  
6 comprising:

7           a transmitter configured to output a local continuous wave signal  
8 and a radio frequency continuous wave signal; and

9           a receiver configured to receive the local continuous wave signal  
10 and a modulated radio frequency continuous wave signal, the receiver  
11 including:

12           a phase shifter configured to adjust a phase angle of the  
13 local continuous wave signal by a phase shift angle, the phase shifter  
14 including a first power divider configured to provide a first component  
15 and a second component of the local continuous wave signal, plural  
16 mixers configured to scale the first component and the second  
17 component using the phase shift angle, and a second power divider  
18 configured to combine the scaled first component and the scaled second  
19 component to provide an adjusted continuous wave signal; and

20           a coupler configured to combine the adjusted continuous  
21 wave signal and the modulated radio frequency continuous wave signal.  
22  
23  
24

15. The interrogator according to claim 14 wherein the first power divider is configured to provide the signal into quadrature components.

16. The interrogator according to claim 14 wherein the first power divider comprises a ninety degree power divider configured to provide the signal into a sine component and a cosine component.

17. The interrogator according to claim 14 further comprising a storage device configured to store plural sine values and plural cosine values and output a sine value and a cosine value individually corresponding to the phase shift angle.

18. The interrogator according to claim 14 further comprising a storage device configured to store a sine value and a cosine value individually corresponding to the phase shift angle.

19. The interrogator according to claim 18 wherein the mixers are coupled with the storage device and individually configured to multiply one of the first and second components by one of the sine value and the cosine value.

1           20. The interrogator according to claim 14 wherein the second  
2 power divider comprises a zero degree power divider configured to add  
3 the scaled first component and the scaled second component.

4  
5           21. A phase shifter comprising:

6           a first input configured to receive a signal having a phase angle;

7           a second input configured to receive a phase shift angle;

8           a storage device configured to receive the phase shift angle, to  
9 store plural sine values and plural cosine values, and to output the sine  
10 value and cosine value which correspond to the phase shift angle;

11           a ninety degree power divider coupled with the first input and  
12 configured to provide the signal into a sine component and a cosine  
13 component;

14           a first mixer coupled with the ninety degree power divider and  
15 the storage device and configured to multiply the sine component of the  
16 signal by the sine value corresponding to the phase shift angle;

17           a second mixer coupled with the ninety degree power divider and  
18 the storage device and configured to multiply the cosine component of  
19 the signal by the cosine value corresponding to the phase shift angle;  
20 and

21           a zero degree power divider coupled with the first mixer and the  
22 second mixer and configured to add the sine component of the signal  
23 and the cosine component of the signal to shift the phase angle of the  
24 signal by the phase shift angle.

1 22. A method of shifting a phase angle of a signal comprising:  
2 providing a signal having a phase angle;  
3 providing a phase shift angle;  
4 providing the signal into a first component and a second  
5 component;

6 scaling the first component using the phase shift angle;  
7 scaling the second component using the phase shift angle;  
8 combining the first component and the second component after the  
9 scalings to shift the phase angle of the signal by the phase shift angle.

10  
11 23. The method according to claim 22 wherein the providing the  
12 signal into a first component and a second component comprises  
13 providing the signal into quadrature components.

14  
15 24. The method according to claim 22 wherein the providing the  
16 signal into a first component and a second component comprises  
17 providing the signal into a sine component and a cosine component.

18  
19 25. The method according to claim 22 further comprising:  
20 storing a plurality of sine values and cosine values; and  
21 outputting one sine value and one cosine value individually  
22 corresponding to the phase shift angle.

1           26. The method according to claim 22 further comprising storing  
2 a sine value and a cosine value individually corresponding to the phase  
3 shift angle.

4  
5           27. The method according to claim 26 wherein the scalings  
6 individually comprise multiplying one of the first component and the  
7 second component by one of the sine value and the cosine value.

8  
9           28. The method according to claim 22 wherein the combining  
10 comprises adding the scaled first component and the scaled second  
11 component.

12  
13           29. A method of shifting the phase angle of a signal comprising:  
14 providing a signal having a phase angle;  
15 providing a phase shift angle;  
16 providing the signal into a sine component and a cosine  
17 component;

18           multiplying the sine component by a sine value corresponding to  
19 the phase shift angle;

20           multiplying the cosine component by a cosine value corresponding  
21 to the phase shift angle; and

22           adding the sine component and the cosine component after the  
23 multiplyings to shift the phase angle of the signal by the phase shift  
24 angle.

1           30. The method according to claim 29 further comprising storing  
2 a plurality of sine values and cosine values and outputting a sine value  
3 and a cosine value individually corresponding to the phase shift angle.  
4

5           31. The method according to claim 29 wherein the providing the  
6 signal into a sine component and a cosine component comprises  
7 providing using a ninety degree power divider.  
8

9           32. The method according to claim 29 wherein the multiplying  
10 individually comprise multiplying using a mixer.  
11

12           33. The method according to claim 29 wherein the combining  
13 comprises adding the scaled first component and the scaled second  
14 component.  
15

16           34. The method according to claim 29 wherein the adding  
17 comprises adding using a zero degree power divider.  
18  
19  
20  
21  
22  
23  
24

1           35. A method of operating a coherent interrogator of a  
2 backscatter communication system comprising:

3           outputting a radio frequency continuous wave signal;

4           providing a local continuous wave signal;

5           receiving a modulated continuous wave signal;

6           providing a phase shift angle;

7           adjusting the phase of the local continuous wave signal using the  
8 phase shift angle to provide an adjusted continuous wave signal, the  
9 adjusting including:

10           providing the local continuous wave signal into a first  
11 component and a second component;

12           scaling the first component using the phase shift angle;

13           scaling the second component using the phase shift angle;

14           and

15           combining the first component and the second component  
16 after the scalings to shift the phase angle of the local continuous wave  
17 signal by the phase shift angle; and

18           combining the adjusted continuous wave signal and the modulated  
19 continuous wave signal.

20  
21           36. The method according to claim 35 wherein the providing the  
22 signal into a first component and a second component comprises  
23 providing the signal into quadrature components.  
24



37. The method according to claim 35 wherein the providing the signal into a first component and a second component comprises providing the signal into a sine component and a cosine component.

38. The method according to claim 35 further comprising storing a plurality of sine values and cosine values and outputting a sine value and a cosine value individually corresponding to the phase shift angle.

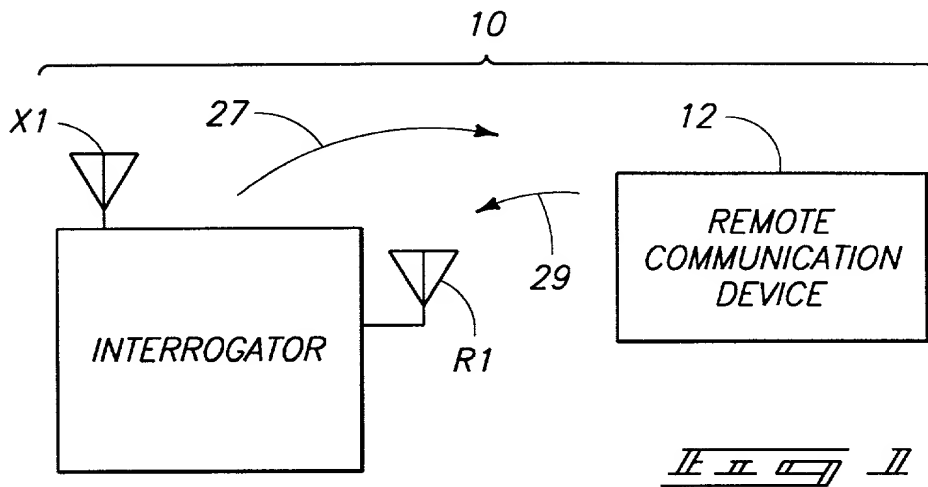
39. The method according to claim 35 further comprising storing a sine value and a cosine value individually corresponding to the phase shift angle.

40. The method according to claim 39 wherein the scalings individually comprise multiplying one of the first component and the second component by one of the sine value and the cosine value.

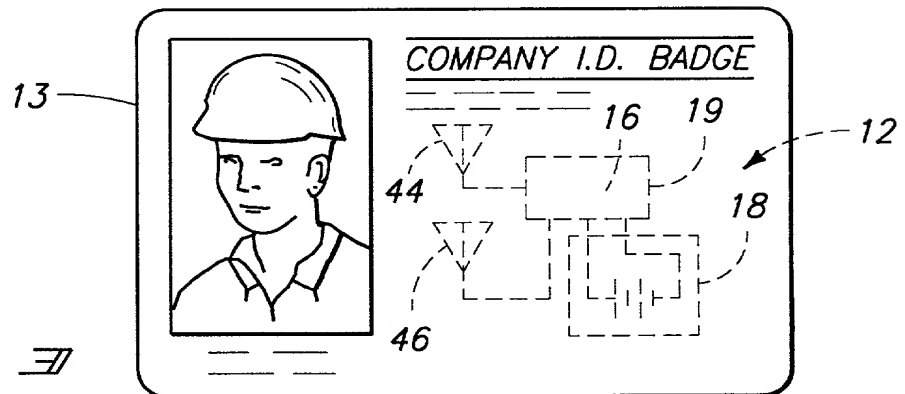
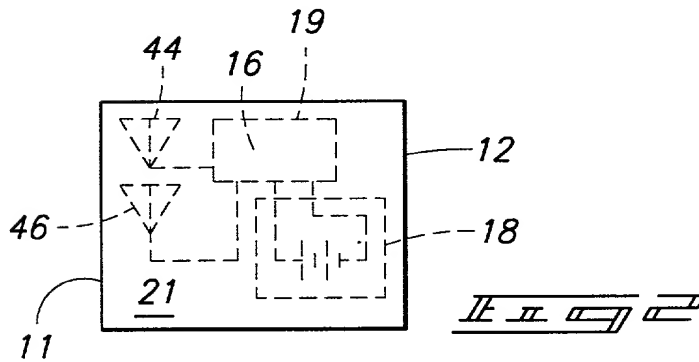
41. The method according to claim 35 wherein the combining comprises adding the scaled first component and the scaled second component.

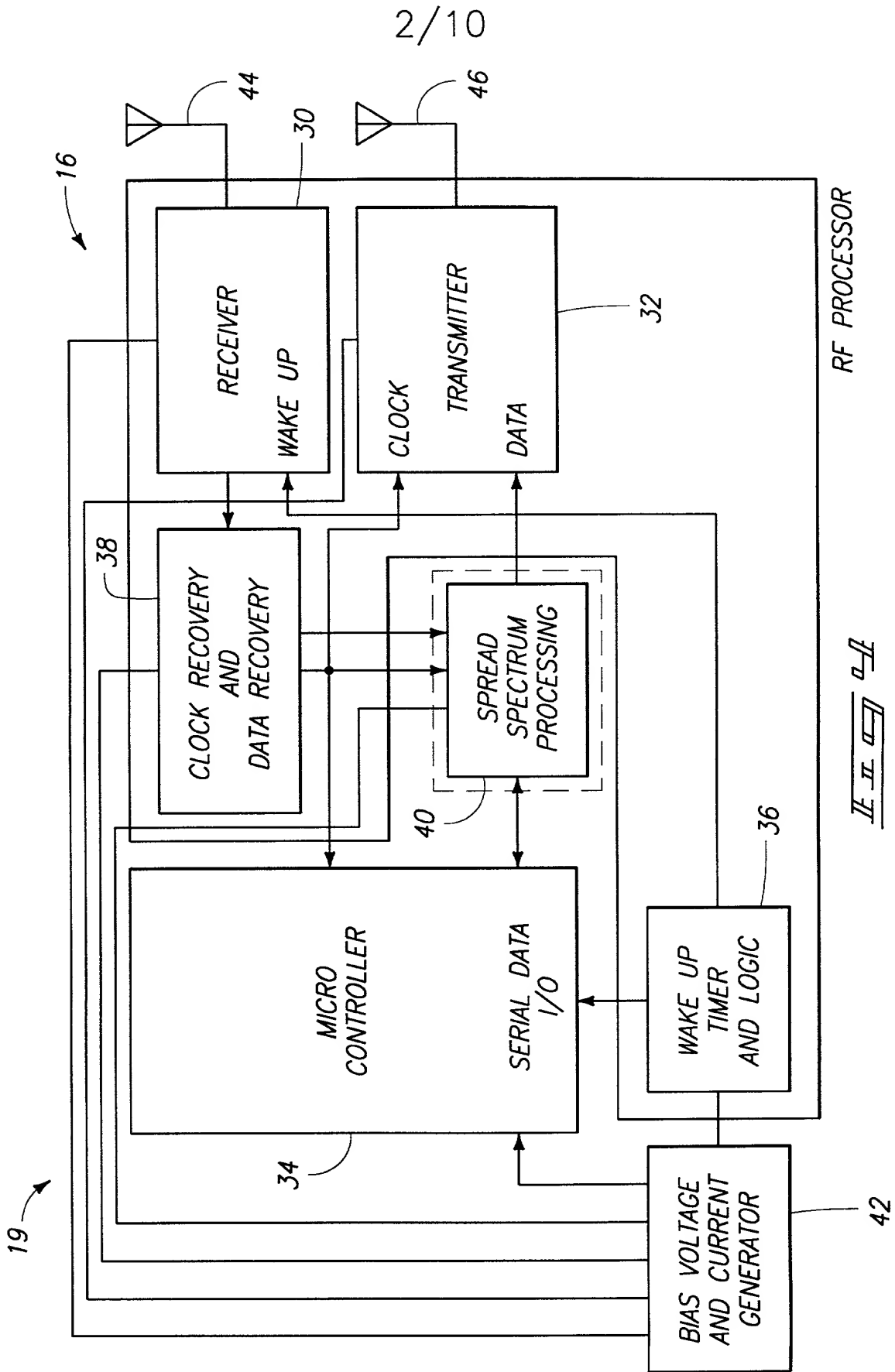


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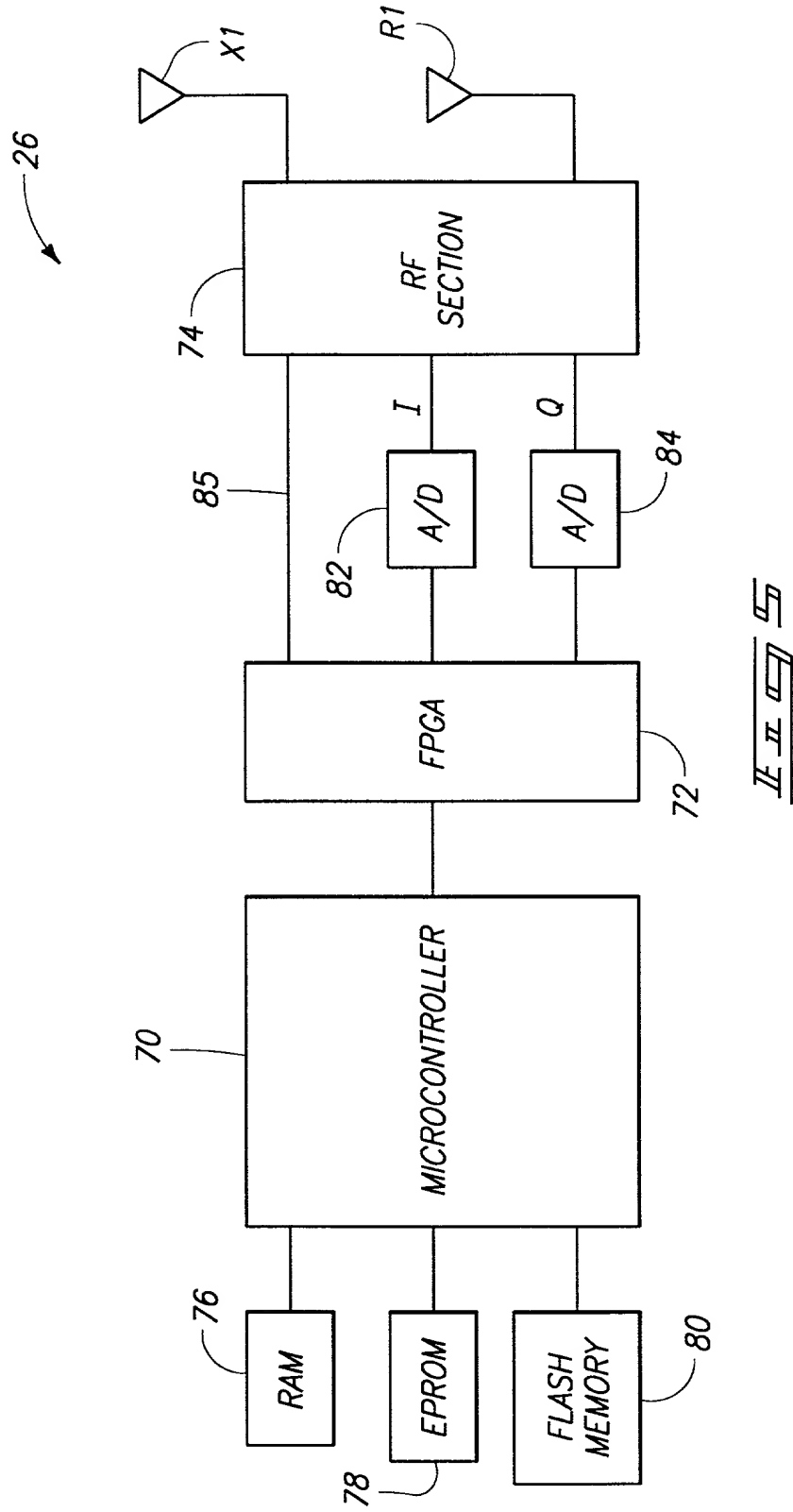


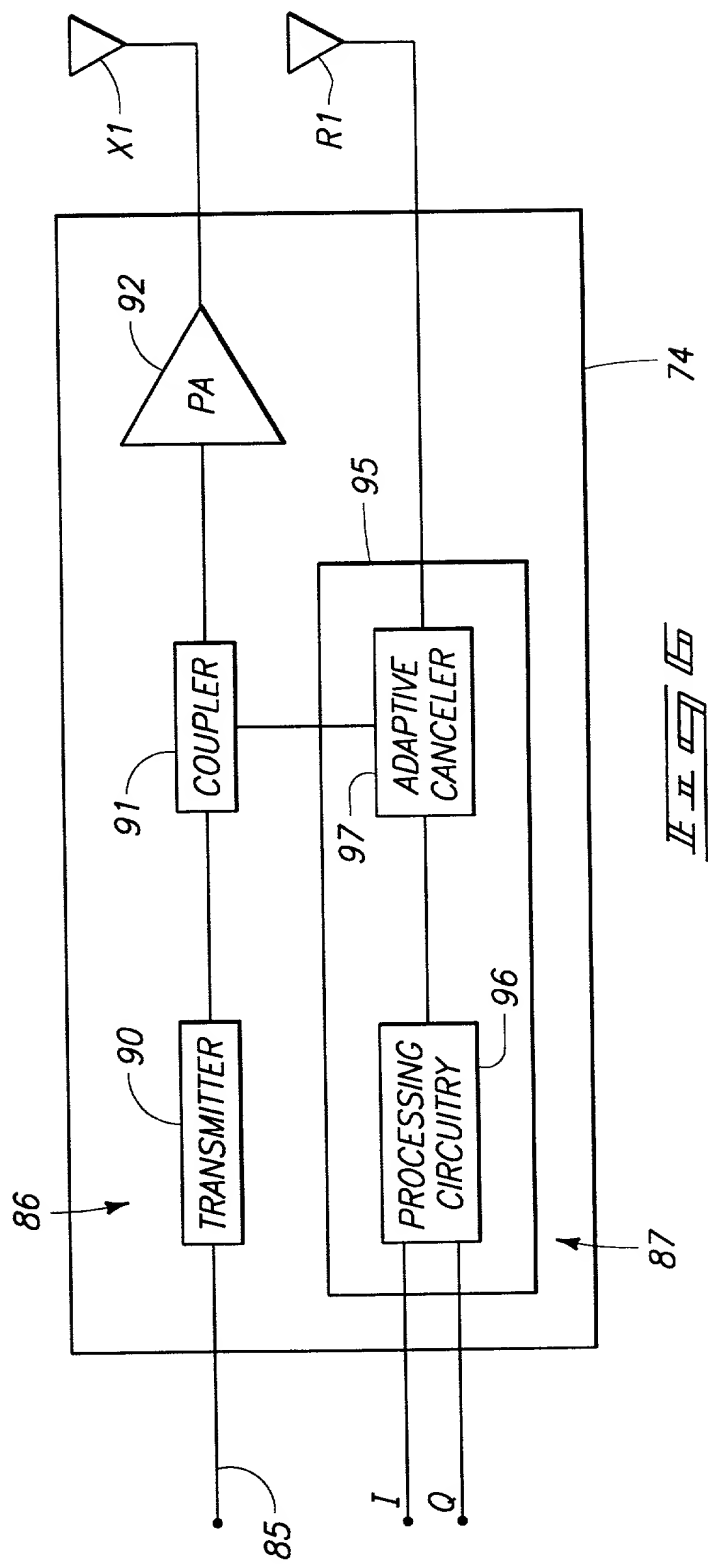
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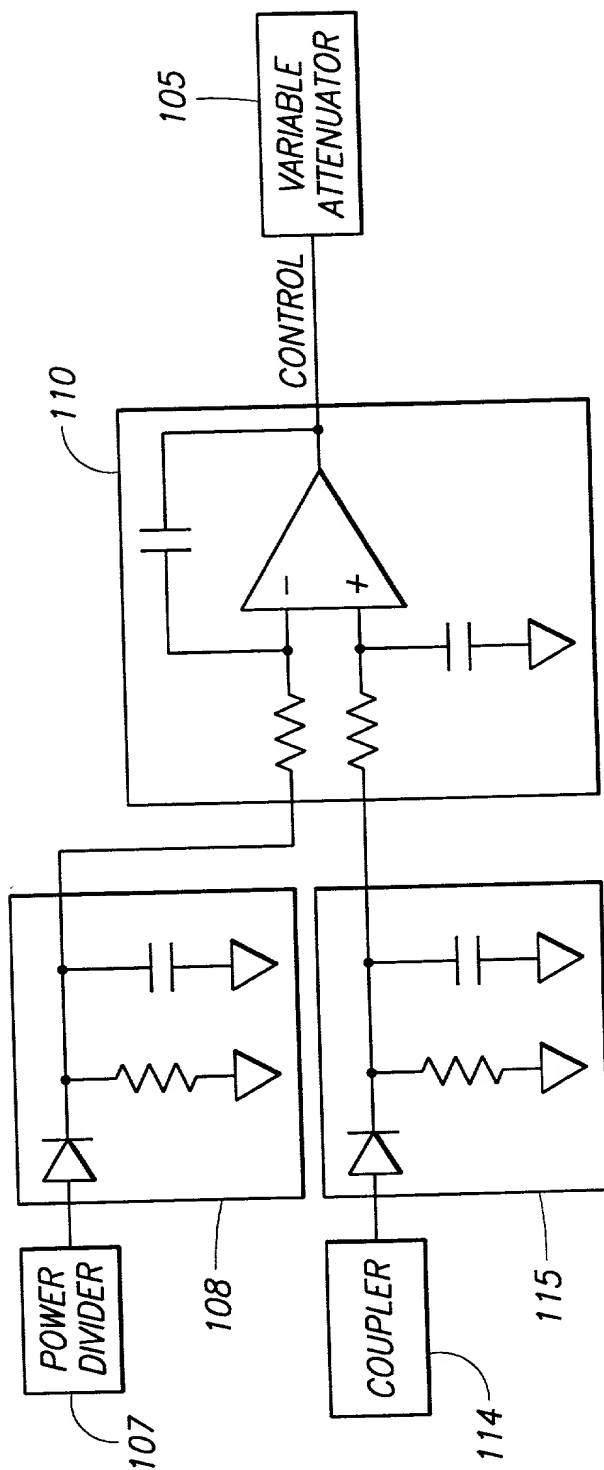
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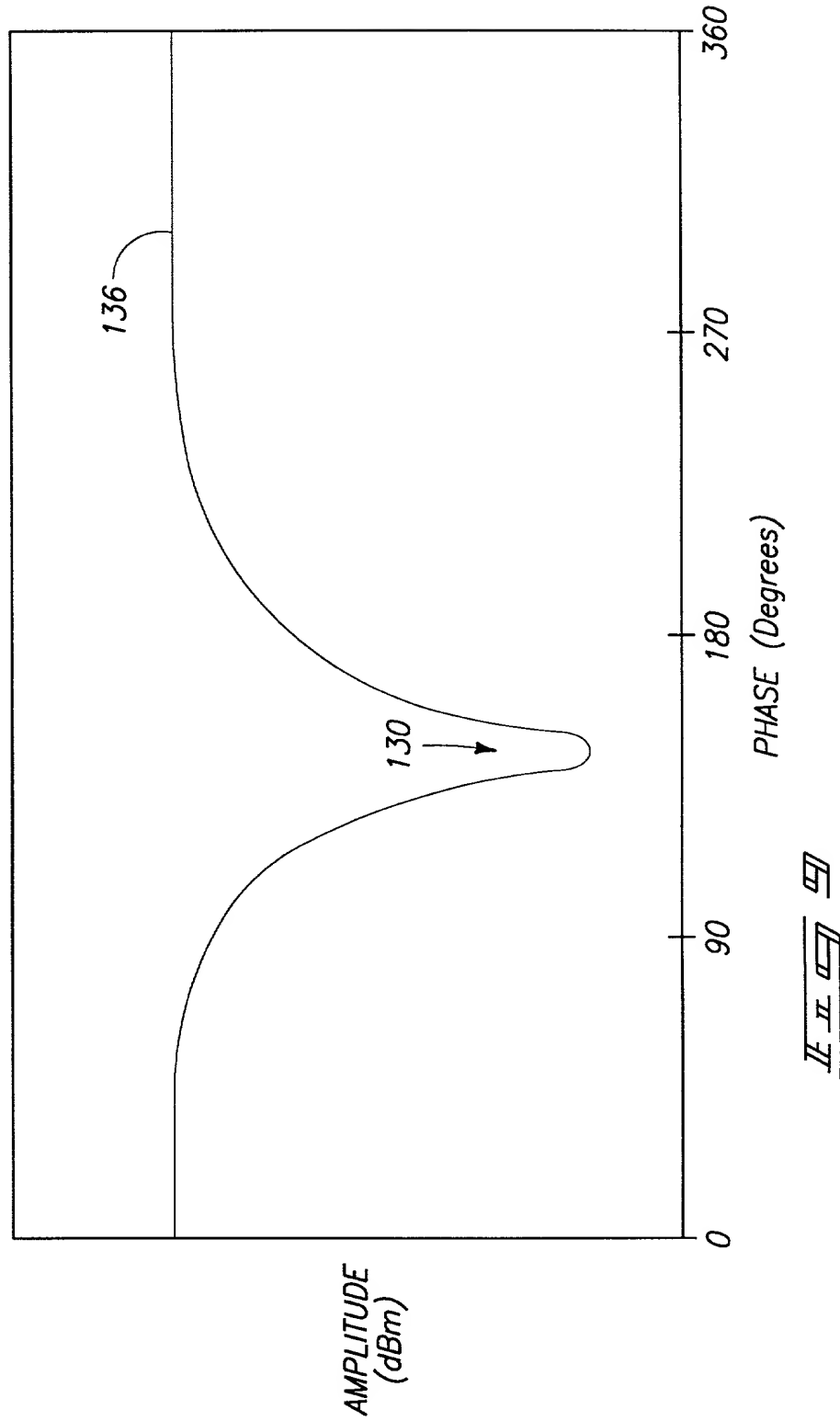
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SECRET



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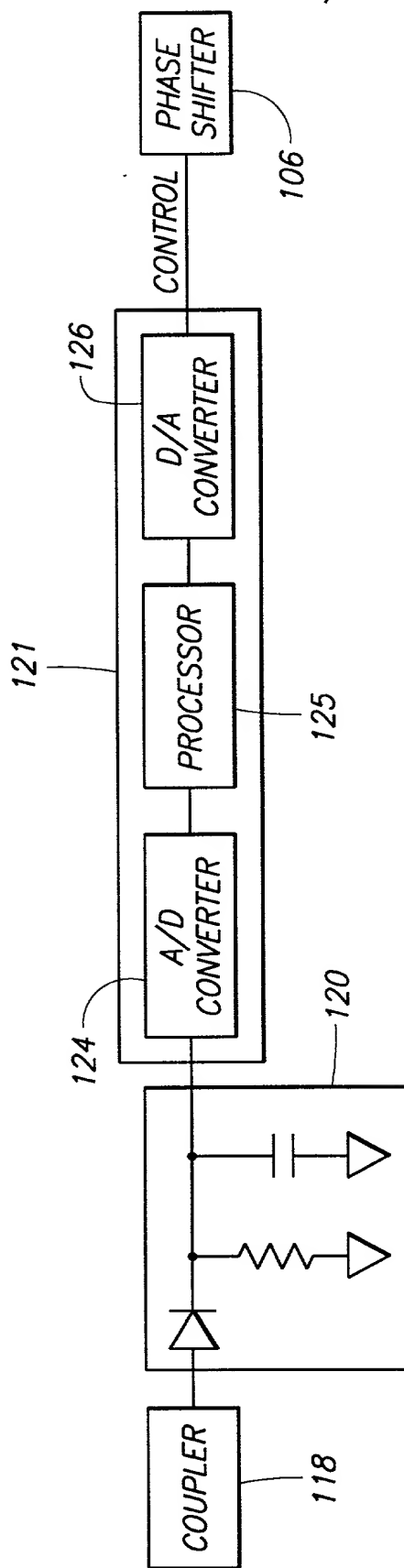
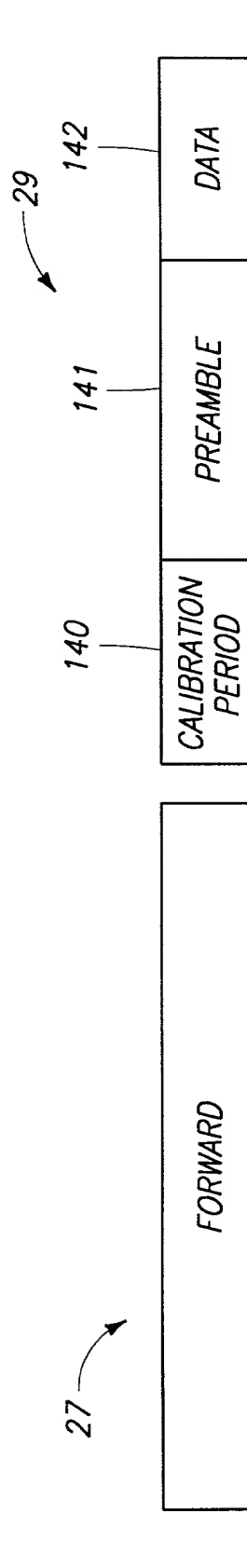
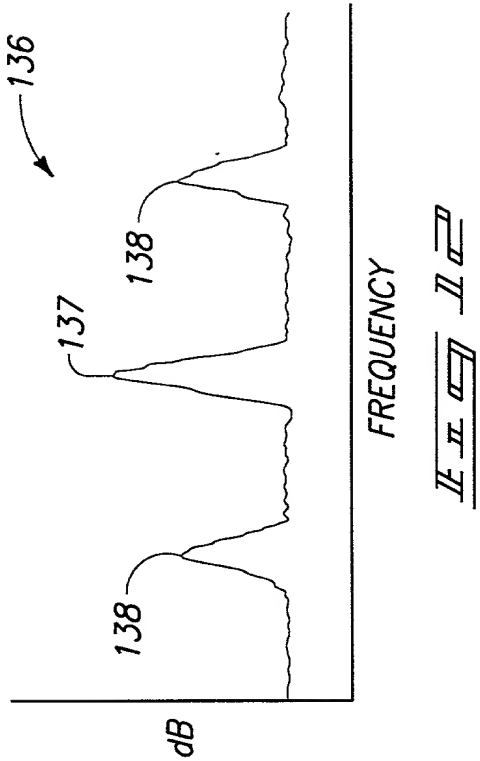
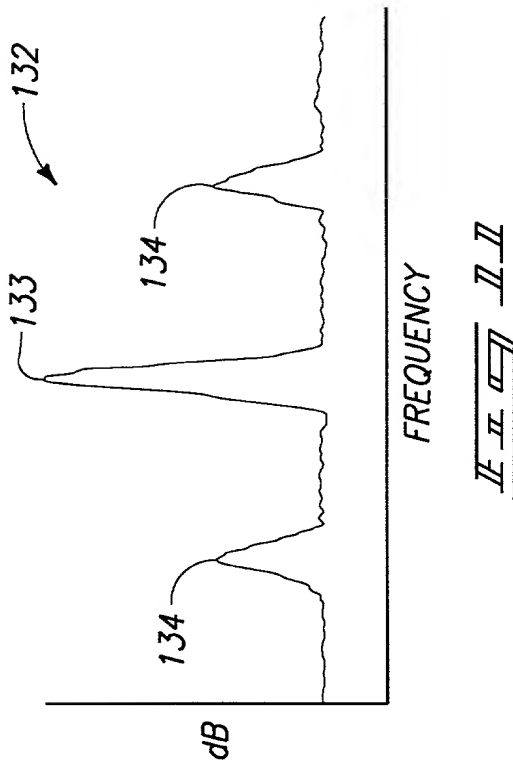
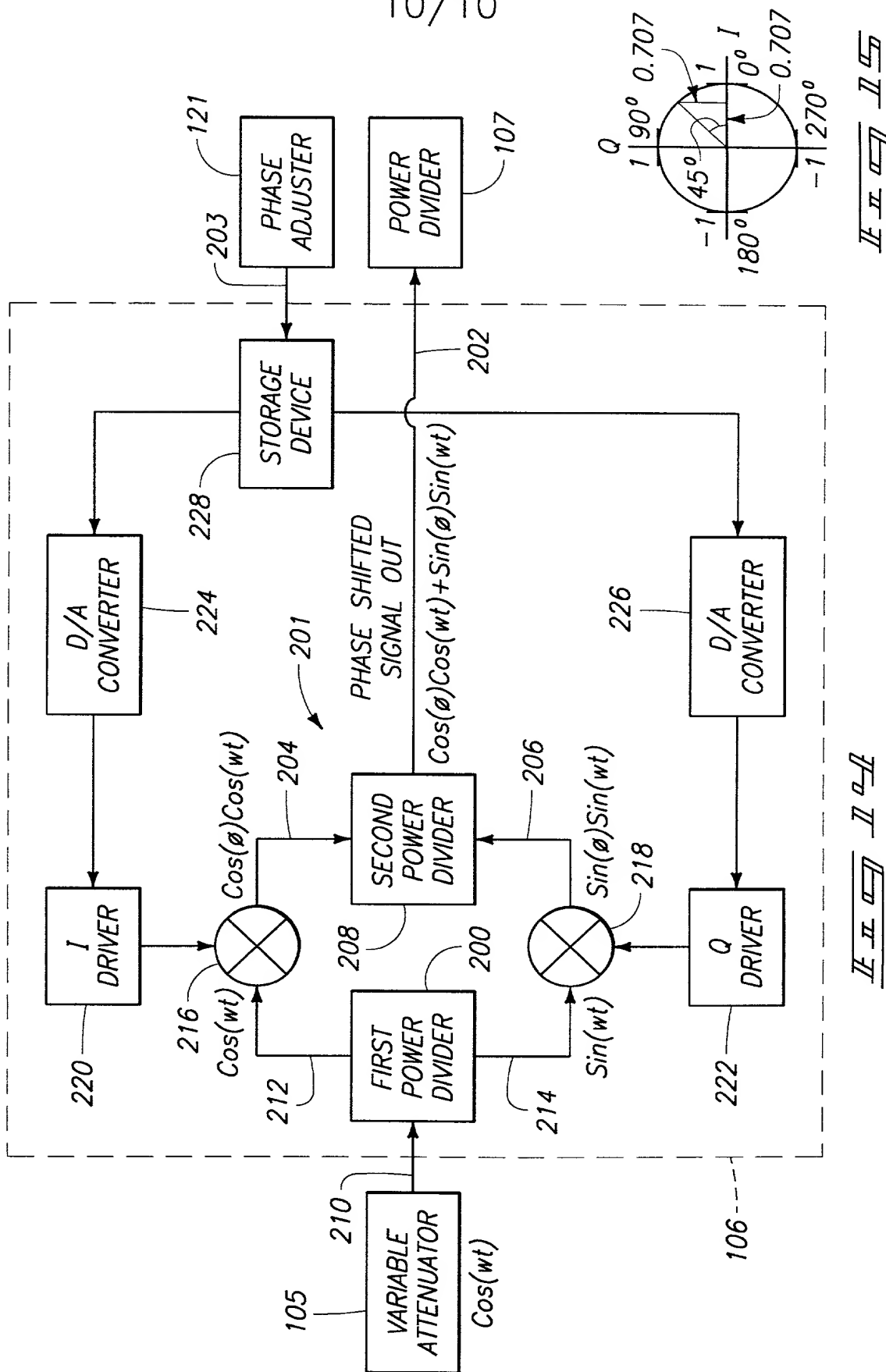


FIG. 8



II II II II



1                   **IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

2   Application Serial No. .... Unknown  
 3   Filing Date ..... Filed herewith  
 4   Inventor ..... Roy Greeff et al.  
 5   Assignee ..... Micron Communications, Inc.  
 6   Group Art Unit ..... Unknown  
 7   Examiner ..... Unknown  
 8   Attorney's Docket No. .... MI40-177  
 9   Title: Phase Shifters, Interrogators, Methods of Shifting a Phase Angle of a Signal,  
 10       and Methods of Operating an Interrogator

11                   **POWER OF ATTORNEY BY ASSIGNEE AND**  
 12                   **CERTIFICATE BY ASSIGNEE UNDER 37 CFR §3.73(b)**

13   To:   Assistant Commissioner for Patents  
 14       Washington, D.C. 20231

15   Sir:

16                   **MICRON COMMUNICATIONS, INC.**, the Assignee of the entire  
 17   right, title and interest in the above-identified patent application by  
 18   assignment attached hereto, hereby appoints the attorneys and agents of  
 19   the firm of WELLS, ST. JOHN, ROBERTS, GREGORY & MATKIN  
 20   P.S., listed as follows:

21           Richard J. St. John	Reg. No. 19,363
22           David P. Roberts	Reg. No. 23,032
23           Randy A. Gregory	Reg. No. 30,386
24           Mark S. Matkin	Reg. No. 32,268
James L. Price	Reg. No. 27,376
Deepak Malhotra	Reg. No. 33,560
Mark W. Hendricksen	Reg. No. 32,356
David G. Latwesen	Reg. No. 38,533
George G. Grigel	Reg. No. 31,166
Keith D. Grzelak	Reg. No. 37,144
Lance R. Sadler	Reg. No. 38,605
James D. Shaurette	Reg. No. 39,833

1 and also attorneys Michael L. Lynch (Reg. No. 30,871) and Lia Pappas  
2 Dennison (Reg. No. 34,095) of Micron Communications, Inc., as its  
3 attorneys with full power of substitution to prosecute this application and  
4 transact all business in the Patent and Trademark Office connected  
5 therewith.

6 The Assignee certifies that the above-identified Assignment has  
7 been reviewed and to the best of Assignee's knowledge and belief, title  
8 is in the Assignee.

9 Please direct all correspondence regarding this application to:

10 Wells, St. John, Roberts, Gregory & Matkin P.S.  
11 Attn: James D. Shaurette  
601 West First Avenue, Suite 1300  
12 Spokane, WA 99201-3828

13 Telephone: (509) 624-4276  
Facsimile: (509) 838-3424

14 MICRON COMMUNICATIONS, INC.

15  
16 Dated: 3/2/99

By: 

17 Name: James E. O'Toole  
18 Title: Chairman and President  
19  
20  
21  
22  
23  
24

**DECLARATION OF JOINT INVENTORS FOR PATENT APPLICATION**

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: Phase Shifters, Interrogators, Methods of Shifting a Phase Angle of a Signal, and Methods of operating an Interrogator, the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations §1.56.

**PRIOR FOREIGN APPLICATIONS:**

I hereby state that no applications for foreign patents or inventor's certificates have been filed prior to the date of execution of this declaration.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful

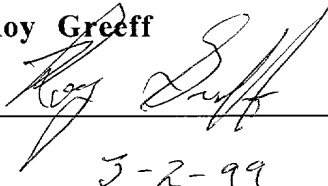
1 false statement may jeopardize the validity of the application or any  
2 patent issued therefrom.

3 \* \* \* \* \*

4 Full name of inventor:

**Roy Greeff**

5 Inventor's Signature:



6 Date:

5-2-99

7 Residence:

**Boise, Idaho**

8 Citizenship :

**United States of America**

9 Post Office Address:

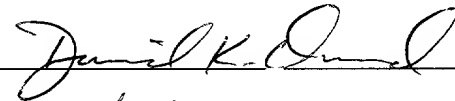
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Boise, Idaho 83709**

10 \* \* \* \* \*

11 Full name of inventor:

**David K. Ovard**

12 Inventor's Signature:



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3/2/99

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